Claims

Claim 1. Extrusion die apparatus, for manufacturing blown plastic film, wherein:

the apparatus includes a die-member;

the die-member is of generally annular form, having a circumferentially-disposed outer-face and inner-face;

the die-member has a groove-face-A, which is of annular configuration, and which has an inner-edge-A;

the groove-face-A is formed with melt-conveying-channels-A;

the die-member includes a melt-entry-port, which is located in the outer-face of the die-member;

the apparatus includes an annular groove-opposing-surface-A;

the melt-conveying-channels-A include N spiral-grooves-A, which are open, and are formed into the groove-face-A;

the apparatus is so arranged that melt, in flowing towards the inner-edge-A, spills over lands between turns of the spiral-grooves-A;

the melt-conveying-channels-A are arranged, in relation to the groove-opposing-surface-A, for conveying liquid melt under pressure from the melt-entry-port in the outer-face, in a progressively inwards sense, through the spiral-grooves-A, to the inner-edge-A of the groove-face-A;

the melt-conveying-channels-A include at least N supply-channels-A;

the melt-conveying-channels-A include flow-divider-channels-A, which receive melt from the melt-entry-port, and divide the same into at least N incoming-streams, and convey the incoming-streams one each into the supplu-channels-A respectively;

the melt-conveying-channels-A include flow-mixing-channels-A;

the flow-mixing-channels-A include subdivider-junctions-A and recombiner-junctions-A;

at the subdivider-junctions-A, respective ones of the at least N incoming-streams from the supply-channels-A are sub-divided into

respective left and right subdivided-streams;

the recombiner-junctions are positioned inwards of the subdivider-junctions, and between adjacent subdivider-junctions, in the sense of being positioned to receive the subdivided-streams moving inwards from the adjacent subdivider-junctions;

the melt-conveying-channels are so configured that, in respect of each one of the recombiner-junctions, the recombiner-junction receives the left subdivided-stream from the adjacent one of the subdivider-junctions to the right of that recombiner-junction, and receives the right subdivided-stream from the adjacent one of the subdivider-junctions to the left of that recombiner-junction, and combines the said left and right subdivided-streams into one recombined-stream respective to that recombiner-junction;

the melt-conveying-channels-A include N of the recombiner-junctions, and the arrangement of the melt-conveying-channels is such that the N recombined-streams flow inwards, one each respectively, to the N spiral-grooves-A;

and the melt-conveying-channels-A are so arranged as to convey melt from the melt-entry-port in the outer-face inwards first through the flow-divider-channels, then inwards through the supply-channels-A, then inwards through the flow-mixing-channels-A, then inwards through the spiral-grooves-A, then inwards towards the inner-edge-A of the groove-face-A.

Claim 2. Apparatus of claim 1, wherein N = a number in the series 2,4,8,16...

Claim 3. Apparatus of claim 2, wherein N = 4.

Claim 4. Apparatus of claim 1, wherein the groove-opposing-surface-A is a smooth flat plane, the groove-face-A being correspondingly flat.

Claim 5. Apparatus of claim 1, wherein the groove-opposing-surface-A is a concave frustum of a right cone, the groove-face-A being correspondingly convexly conical.

Claim 6. Apparatus of claim 1, wherein the flow-divider-channels-A and the flow-mixing-channels-A comprise open grooves, which are formed into the groove-face-A.

Claim 7. Apparatus of claim 1, wherein:

the arrangement of the apparatus is such that the spiral-grooves receive liquid-melt that has passed from the melt-entry-port along respective pathways within the melt-conveying-channels-A;

the respective pathways are of equal length, and of equal number of divisions and confluences, and of equal tortuousnesses.

lands between grooves.

Claim 8. Apparatus of claim 1, wherein:

the N spiral-grooves-A include spiral-groove-F and spiral-groove-G, spiral-groove-G being the next-adjacent spiral-groove to the right of spiral-groove-F;

start-groove-F is the respective start-channel-A to spiral-groove-F;

start-groove-G is the respective start-channel-A to spiral-groove-G, whereby start-groove-G lies to the right of start-groove-F;

supply/feed-junction-FG is the respective supply/feed-junction located between the start-channel-F and the start-channel-G;

feed-groove-FG-F is the respective feed-channel that runs leftwards from the supply/feed-junction-FG to the start-groove-F;

feed-groove-FG-G is the respective feed-channel that runs rightwards from the supply/feed-junction-FG to the start-groove-G;

base-land-FG is the area bounded by and between the following grooves: spiral-groove-F; start-groove-F and start-groove-G; feed-groove-FG-F and feed-groove-FG-G;

radial lines drawn on the annular groove-face-A, at a spiral-orientation relative to the datum-point, pass through both the spiral-groove-F and the spiral-groove-G, and through a spiral-land-FG therebetween;

radial lines drawn on the annular groove-face-A, at a base-orientation relative to the datum, pass through spiral-groove-F, and do not pass through spiral-groove-G, and do pass through base-land-FG;

the spiral-land-FG is of such height as to be clear of groove-opposing-surface-A, and to be so clear thereof that melt leaks and spills over the spiral-land-FG, out of spiral-groove-G, and inwards towards the inner-edge-A of the die-member;

the base-land-FG is of such height as to be tight against the groove-opposing-surface-A, whereby substantially no leakage or spillage of melt occurs over the base-land-FG;

the groove-face-A is formed with a step-FG, and the step-FG marks the change in height between the base-land-FG and the spiral-land-FG, in that the base-land-FG lies to the left, and the spiral-land-FG lies to the right, of the step-FG.

Claim 9 Apparatus of claim 8, wherein the change in height between the base-land-FG and the spiral-land-FG, at the step-FG, is at least one millimetre.

Claim 10. Apparatus of claim 8, wherein the step-FG is located adjacent to start-groove-G, in that:

the step-FG marks a first portion of a right-side-boundary of the base-land-FG;

the start-groove-G has a left edge and a right edge;

the edges of the start-groove-G lie approximately radially with respect to the annular groove-face-A;

the left edge of start-groove-G marks a second portion of the right-side-boundary of the base-land-FG;

the said first portion of the right-side-boundary of the base-land-FG is at least approximately contiguous with the said second portion.

Claim 11. Apparatus of claim 10, wherein the step-FG follows a line that lies, at least approximately, on a radius of the annular groove-face-A.

grooves on both sides of die-member

Claim 12. Apparatus of claim 1, wherein the annular die-member has grooves both sides, in that:

the die-member also has a groove-face-B, on the opposite thereof from groove-face-A;

the groove-face-B is of annular configuration, and has an inner-edge-B;

the groove-face-B is formed with melt-conveying-channels-B;

the melt-conveying-channels-B include M spiral-grooves-B, which are open, and are formed into the groove-face-B;

the melt-conveying-channels-B are arranged for conveying liquid melt under pressure from the melt-entry-port in the outer-face, in a progressively inwards sense, through the spiral-grooves-B, to the inner-edge-B of the groove-face-B;

the melt-conveying-channels-A include at least M supply-channels-A;

the melt-conveying-channels-B include flow-divider-channels-B, which receive melt from the melt-entry-port, and divide the same into at least M incoming-streams, and convey the incoming-streams one each into the supplu-channels-A respectively;

the melt-conveying-channels-B include flow-mixing-channels-B;

the flow-mixing-channels-B include subdivider-junctions-B and recombiner-junctions-B;

at the subdivider-junctions-B, respective ones of the at least M incoming-streams from the flow-divider-channels-B are sub-divided

into respective left and right subdivided-streams;

the recombiner-junctions are positioned inwards of the subdivider-junctions, and between adjacent subdivider-junctions, in the sense of being positioned to receive the subdivided-streams moving inwards from the adjacent subdivider-junctions;

the melt-conveying-channels are so configured that, in respect of each one of the recombiner-junctions, the recombiner-junction receives the left subdivided-stream from the adjacent one of the subdivider-junctions to the right of that recombiner-junction, and receives the right subdivided-stream from the adjacent one of the subdivider-junctions to the left of that recombiner junction, and combines the said left and right subdivided-streams into one recombined-stream respective to that recombiner-junction;

the melt-conveying-channels-B include M of the recombiner-junctions, and the arrangement of the melt-conveying-channels is such that the M recombined-streams flow inwards, one each respectively, to the M spiral-grooves-B;

and the melt-conveying-channels-B are so arranged as to convey melt from the melt-entry-port in the outer-face inwards first through the flow-divider-channels, then inwards trhough the supply channels-B, then inwards through the flow mixing-channels-B, then inwards through the spiral-grooves-B, then inwards towards the inner-edge D of the groove face-B.

grooves A and B are both clockwise

Claim 13. Apparatus of claim 12, wherein:

the N spiral-grooves-A have a spiral-sense that is clockwise when viewed from one side of the annular die-member;

the M spiral-grooves-B have a spiral-sense that is also clockwise, when viewed from that same one side of the die-member.

sides A and B have separate melt-entry-channels

Claim 14. Apparatus of claim 12, wherein:

the melt-conveying-channels-A include an entry-channel-A, which is in melt-conveying communication with, and receives melt from, the melt-entry-port;

the entry-channel-A is in melt-conveying communication with N flow-divider-channels-A, which are so arranged as to split the flow from the melt-entry-port equally therebetween;

the N flow-divider-channels are in melt-conveying communication respectively with the N supply-channels-A;

the melt-conveying-channels-A are so arranged as to convey melt from the melt-entry-port to the entry-channel-A, then progressively inwards to the flow-divider-channels-A, and then inwards to the supply-channels-A.

melt entry channels are staggered

Claim 15. Apparatus of claim 14, wherein:

the die-member includes a melt-entry channel A, and the melt, in passing from the melt-entry-port in the outer-face to the melt conveying-channels-A, passes inwards through the melt-entry-channel-A;

the die-member includes a melt-entry-channel-B, and the melt, in passing from the melt-entry-port in the outer-face to the melt-conveying-channels-B, passes inwards through the melt-entry-channel-B;

the arrangement of the apparatus is such that all melt entering the set of melt-conveying-channels-A is melt that has passed through melt-entry-channel-A, and all melt entering the set of melt-conveying-channels-B is melt that has passed through melt-entry-channel-B;

the die-member includes a channel/groove-junction-A, at which melt from the melt entry-channel-A transfers into the set of melt-conveying-channels-A;

the die-member includes a channel/groove-junction-B, at which melt from the melt-entry-channel-B transfers into the set of melt-conveying-channels-B;

with respect to a datum-point on the outer-face of the die-member, channel/groove-junction-A lies orientated at an orientation-angle-A thereto, and channel/groove-junction-B lies orientated at an orientation-angle-B thereto;

and the channel/groove-junction-A is staggered, circumferentially, with respect to channel/groove-junction-B, in that orientation-angle-A is different from orientation-angle-B.

Claim 16. Apparatus of claim 15, wherein the melt-conveying-channels-A are correspondingly offset circumferentially, relative to the datum-point, from the melt-conveying-channels-B.

Claim 17. Apparatus of claim 15, wherein:

the melt-entry-port includes one pipe-connector, whereby the melt-entry-port can be connected by a pipe to a source of pressurised hot melt;

and both melt-entry-channel-A and melt-entry-channel-B are in melt-conveying communication with the one pipe-connector.

Claim 18. Apparatus of claim 15, wherein:

the melt-entry-port includes pipe-connector-A and pipe-connector-B, whereby the melt-entry-port can be connected by pipes to sources of pressurised hot melt;

pipe-connector-A and pipe-connector-B are separate from each other, within the die-member;

melt-entry-channel-A is in melt-conveying communication with pipe-connector-A;

and melt-entry-channel-B is melt-conveying communication with pipe-connector-B.

grooves both sides, staggered ports

Claim 19. Extrusion die apparatus, for manufacturing blown plastic film, wherein:

the apparatus includes a die-member;

the die-member is of generally annular form, having a circumferentially-disposed outer-face and inner-face;

the die-member has opposing side faces, comprising annular groove-face-A and annular groove-face-B, respectively;

groove-face-A meets the inner-face at inner-edge-A, and groove-face-B meets the inner-face at inner-edge-B;

groove-face-A is formed with a set of melt-conveying-channels-A, and groove-face-B is formed with a set of melt-conveying-channels-B;

the die-member includes a melt-entry-port, which is located in the circumferential outer-face of the die-member;

the arrangement of the melt-conveying-channels-A is such that liquid melt passes under pressure from the melt-entry-port, inwards through the set of melt-conveying-channels-A, and inwards to, and over, the inner-edge-A;

the arrangement of the melt-conveying-channel-B is such that liquid melt passes under pressure from the melt-entry-port, inwards through the set of melt-conveying-channels-B, and inwards to, and over, the inner-edge-B;

the die-member includes a melt-entry-channel-A, and the melt, in passing from the melt-entry-port in the outer-face to the set of melt-conveying-channels-A, passes inwards through the melt-entry-channel-A;

the die-member includes a melt-entry-channel-B, and the melt, in passing from the melt-entry-port in the outer-face to the set of melt-conveying-channels-B, passes inwards through the melt-entry-channel-B;

the arrangement of the apparatus is such that all melt entering the

set of melt-conveying-channels-A is melt that has passed through melt-entry-channel-A, and all melt entering the set of melt-conveying-channels-B is melt that has passed through melt-entry-channel-B;

the die-member includes a channel/groove-junction-A, at which melt from the melt-entry-channel-A transfers into the set of melt-conveying-channels-A;

the die-member includes a channel/groove-junction-B, at which melt from the melt-entry-channel-B transfers into the set of melt-conveying-channels-B;

with respect to a datum-point on the outer-face of the die-member, channel/groove-junction-A lies orientated at an orientation-angle-A thereto, and channel/groove-junction-B lies orientated at an orientation-angle-B thereto;

and the channel/groove-junction-A is staggered, circumferentially, with respect to channel/groove-junction-B, in that orientation-angle-A is different from orientation-angle-B.

A and B both clockwise

Claim 20. Extrusion die apparatus, for manufacturing blown plastic film, wherein:

the apparatus includes a die-member;

the die-member is of generally annular form, having a circumferentially-disposed outer-face and inner-face;

the die-member has opposing side faces, comprising annular groove-face-A and annular groove-face-B, respectively;

groove-face-A meets the inner-face at inner-edge-A, and groove-face-B meets the inner-face at inner-edge-B;

groove-face-A is formed with a set of melt-conveying-channels-A, and groove-face-B is formed with a set of melt-conveying-channels-B;

the die-member includes a melt-entry-port, which is located in the circumferential outer-face of the die-member;

the melt-conveying-channels-A include N spiral-grooves-A, which are open, and are formed into the groove-face-A;

the apparatus is so arranged that melt, in flowing towards the inner-edge-A, spills over lands between turns of the spiral-grooves-A;

the melt-conveying-channels-A are arranged for conveying liquid melt under pressure from the melt-entry-port in the outer-face, in a progressively inwards sense, through the spiral-grooves-A, to, and over, the inner-edge-A of the groove-face-A;

the melt-conveying-channels-B include M spiral-grooves-B, which are open, and are formed into the groove-face-B;

the apparatus is so arranged that melt, in flowing towards the inner-edge-B, spills over lands between turns of the spiral-grooves-B;

the melt-conveying-channels-B are arranged for conveying liquid melt under pressure from the melt-entry-port in the outer-face, in a progressively inwards sense, through the spiral-grooves-B, to, and over, the inner-edge-B of the groove-face-B;

the N spiral-grooves-A have a spiral-sense that is clockwise when viewed from one side of the annular die-member;

the M spiral-grooves-B have a spiral-sense that is also clockwise, when viewed from that same one side of the die-member.

grooves in A are circumf offset from grooves in B

Claim 21. Extrusion die apparatus, for manufacturing blown plastic film, wherein:

the apparatus includes a die-member;

the die-member is of generally annular form, having a circumferentially-disposed outer-face and inner-face;

the die-member has opposing side faces, comprising annular groove-face-A and annular groove-face-B, respectively;

groove-face-A meets the inner-face at inner-edge-A, and groove-face-B meets the inner-face at inner-edge-B;

groove-face-A is formed with a set of melt-conveying-channels-A, and

groove-face-B is formed with a set of melt-conveying-channels-B;

the die-member includes a melt-entry-port, which is located in the circumferential outer-face of the die-member;

the melt-conveying-channels-A include N spiral-grooves-A, which are open, and are formed into the groove-face-A;

the apparatus is so arranged that melt, in flowing towards the inner-edge-A, spills over lands between turns of the spiral-grooves-A;

the melt-conveying-channels-A are arranged for conveying liquid melt under pressure from the melt-entry-port in the outer-face, in a progressively inwards sense, through the spiral-grooves-A, to, and over, the inner-edge-A of the groove-face-A;

the melt-conveying-channels-B include M spiral-grooves-B, which are open, and are formed into the groove-face-B;

the apparatus is so arranged that melt, in flowing towards the inner-edge-B, spills over lands between turns of the spiral-grooves-B;

the melt-conveying-channels-B are arranged for conveying liquid melt under pressure from the melt-entry-port in the outer-face, in a progressively inwards sense, through the spiral-grooves-B, to, and over, the inner-edge-B of the groove-face-B;

with respect to a datum-point on the outer-face of the die-member, melt-conveying-channels-A in groove-face-A lie orientated at an orientation-angle-A thereto, and melt-conveying-channels-B in groove-face-B lie orientated at an orientation-angle-B thereto;

and the groove-face-A is staggered, circumferentially, with respect to the groove-face-B, in that orientation-angle-A is different from orientation-angle-B.

separate indept claim to flow mixing channels, based on channels rather than flow-streams

Claim 22. Extrusion die apparatus, for manufacturing blown plastic film, wherein:

the apparatus includes a first-grooved-die-member;

the first-grooved-die-member is of generally annular form, and has a circumferential first-outer-face;

the first-grooved-die-member has a groove-face-A, which is of annular configuration, and which has an inner-edge-A;

the groove-face-A is formed with melt-conveying-channels-A;

the first-grooved-die-member includes a melt-entry-port;

the melt-entry-port is located in the first-outer-face;

the apparatus includes a second-die-member;

the second-die-member is formed with an annular groove-opposing-surface-A;

the melt-conveying-channels-A include a set of N spiral-grooves-A, which are open, and are formed into the groove-face-A;

the melt-conveying-channels-A include a set of N start-channels-A, the arrangement of which is such that the spiral-grooves-A are in melt-conveying-communication with respective ones of the start-channels-A;

the groove-face-A being in operative contact with the groove-opposing-surface-A, the melt-conveying-channels-A are arranged suitably for conveying liquid melt under pressure from the melt-entry-port in the first-outer-face, in a progressively inwards sense, to the inner-edge-A of the groove-face-A;

the melt-conveying-channels-A include a set of 2N feed-channels-A;

the melt-conveying-channels-A include a set of N supply-channels-A;

the arrangement of the melt-conveying-channels-A is such that liquid melt passes under pressure from the melt-entry-port inwards first to the supply-channels-A, then inwards to the feed-channels-A, then inwards to the start-channels-A, then inwards to the spiral-grooves-A, then inwards to the inner-edge-A of the groove-face-A;

the melt-conveying-channels-A include N supply/feed-junctions-A, and N feed/start-junctions-A;

at the supply/feed-junctions-A, the supply-channels-A communicate with respective pairs of the feed-channels-A, and the arrangement of

the apparatus is such that the streams of melt flowing inwards from the respective supply-channel-A divide each into two streams, one in each of the respective pair of feed-channels-A;

at the feed/start-junctions-A, the start-channels communicate with respective couples of the feed-channels-A, and the arrangement of the apparatus is such that, in respect of each one of the feed/start-junctions-A, the two streams of melt flowing inwards from the respective couple of the feed-channels-A combine together into a single stream, in the respective one of the start-channels-A.